$10.00

STRIKE FINDER

DIGITAL WEATHER AVOIDANCE

Pinpoint Lightning Strikes with Digital Accuracy

PILOT'S GUIDE

Insight
Avionics Inc.

www.insightavionics.com

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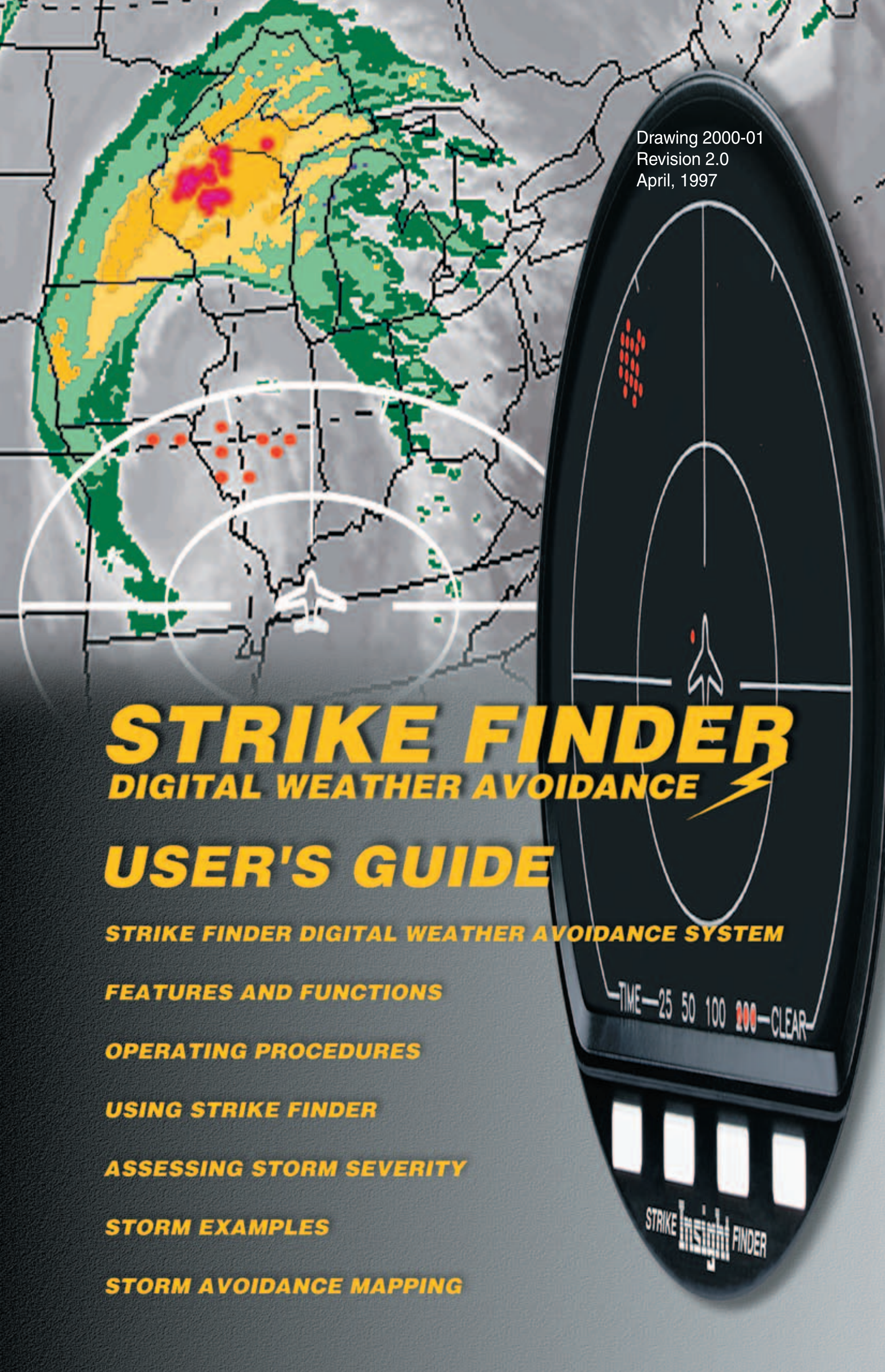

STRIKE FINDER

DIGITAL WEATHER AVOIDANCE

USER'S GUIDE

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STRIKE FINDER
DIGITAL WEATHER AVOIDANCE SYSTEM

Cautionary Notice

Strike Finder is an electromagnetic signal detection and mapping system. Lightning is a characteristic of thunderstorms and Strike Finder is an effective device for locating that phenomenon. Most hazards of the thunderstorm coincide with the approximate location of lightning and heavy rainfall. Although this relationship exists, it is neither precise nor 100% accurate. A wide avoidance path ensures that Strike Finder serves the cause of safety.

No storm avoidance product today, Strike Finder included, is designed to enable, or encourage, penetration of convective buildups and/or thunderstorms. The best application of all such devices, is to find the best routes clear of weather threats.

The Strike Finder mission is exclusively avoidance!

Warning

Insight Strike Finder Weather Mapping System is not intended for thunderstorm penetration. There is no instrument available that will allow you to safely navigate into a thunderstorm.

Warranty

Insight Avionics Inc.'s Strike Finder Weather Mapping System is warranted against defects in materials and workmanship for two years from date of purchase. Insight will, at its option, repair or replace, without charge, those products that it finds defective. The installation is warranted by the installing dealer. Insight will not be responsible for repairs required by improper installation, unauthorized maintenance or abuse. No other warranty is expressed or implied. Insight is not liable for consequential damages.

Introduction

The **Strike Finder Digital Weather Avoidance System** detects and analyzes the electrical activity emanating from thunderstorms within a 200 nautical mile (nm) radius of the aircraft. A unique graphic display plots an accurate, reliable and easily-interpreted picture of electrical activity that you can use to circumnavigate the hazards associated with thunderstorms.

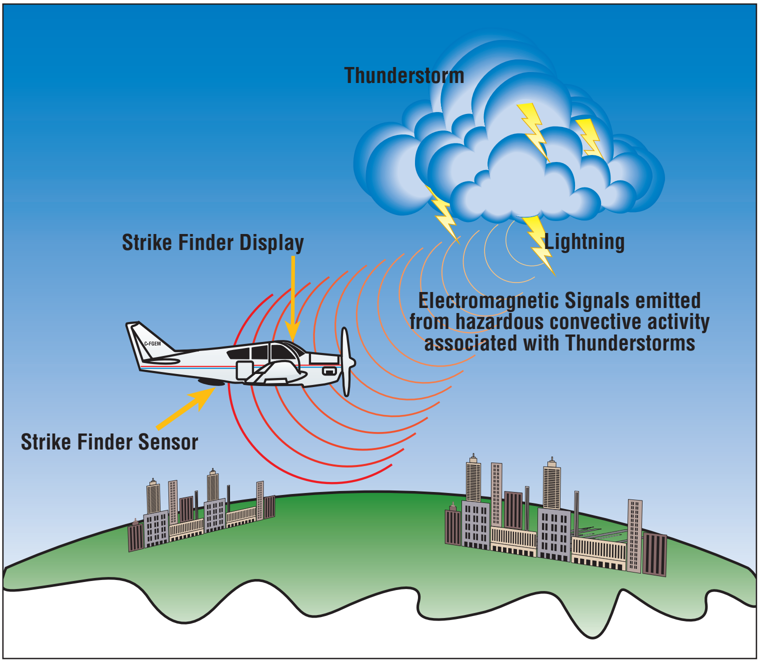


Figure 1. Functional Graphic

Functional Description

The Strike Finder Sensor routinely receives the electromagnetic signals emitted by lightning *(see Figure 1)*. This information is amplified and conveyed by a shielded cable to the Display, where the advanced technology of **Digital Signal Processing** analyzes the severity and location of the thunderstorms. The ultra bright **LED display** plots the information as **strike dots** and **cells**, in one cohesive easy-to-interpret weather picture *(see Figure 2)*.

Viewing the Display

The Strike Finder System analyzes the individual strike signal properties to determine the bearing, range and severity of the activity. **Strike data** is plotted on the display as single orange dots by range and azimuth, in relation to the aircraft symbol ("heads up"). As the number of lightning strikes increase, so does the number of plotted **strike dots**. **Cells** start to form indicating increased lightning activity *(see Figure 2)*.

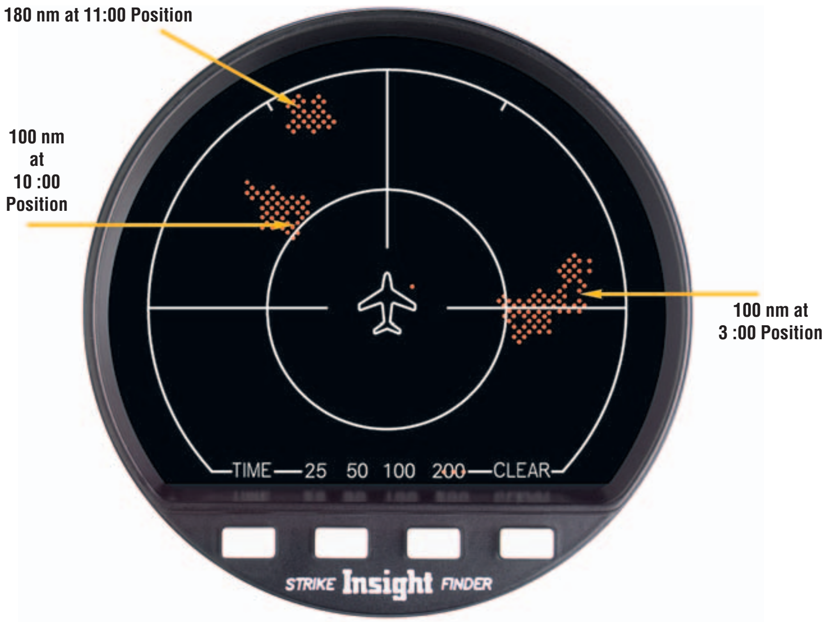


Figure 2. Typical Weather On 200 nm Range View

Bearing and Range

Storm distance and bearing can be determined by using the **Outer Range Ring** and the **Half Range Ring**, in conjunction with the **30-degree Azimuth** (1:00 and 11:00) markers *(see Figure 4)*.

The **Outer Range Ring** is the outer boundary distance from your aircraft that **strike dots** are plotted in the selected range. The **Half Range Ring** is exactly half that distance from your aircraft. For example, 200 nm range selection gives a Half Range Ring distance of 100 nm).

Strike Finder System Components

Strike Finder has two components: *Figure 3* shows the Display and Sensor. These two components are connected with a shielded cable.

Figure 3. System Components: Display and Sensor

Display

The Display mounts in the aircraft instrument panel. The Strike Finder can be slaved directly to an HSI or compass system with a standard stepper or synchro-output. The display consists of two components: an **Ultra Bright LED** or **Gas Plasma Display** and a single microprocessor-based circuit board that employs **Digital Signal Processing**, to ensure that the truest possible storm image is displayed. The microprocessor constantly monitors the performance of the entire system, from the Sensor to the Display for proper function.

Sensor

The maintenance-free Sensor is weather-sealed and mounts on the outside of the aircraft fuselage. Strike Finder, unlike any other system, uses **Broad-band Digital Sampling**. A greater bandwidth delivers vastly more information for improved signal fidelity and inherently superior noise rejection. This translates into a clearer definition of weather activity, without false or misleading indications.

Relative Bearing Stabilizer (RBS)

Recognizing that not all aircraft are equipped with a slaved compass system, Insight developed a revolutionary **Relative Bearing Stabilizer** for Strike Finder. The self contained, solid state, gyro-less design, installs in minutes and will require no adjustment or overhaul, *(see Appendix D section for more details).*

FEATURES AND FUNCTIONS

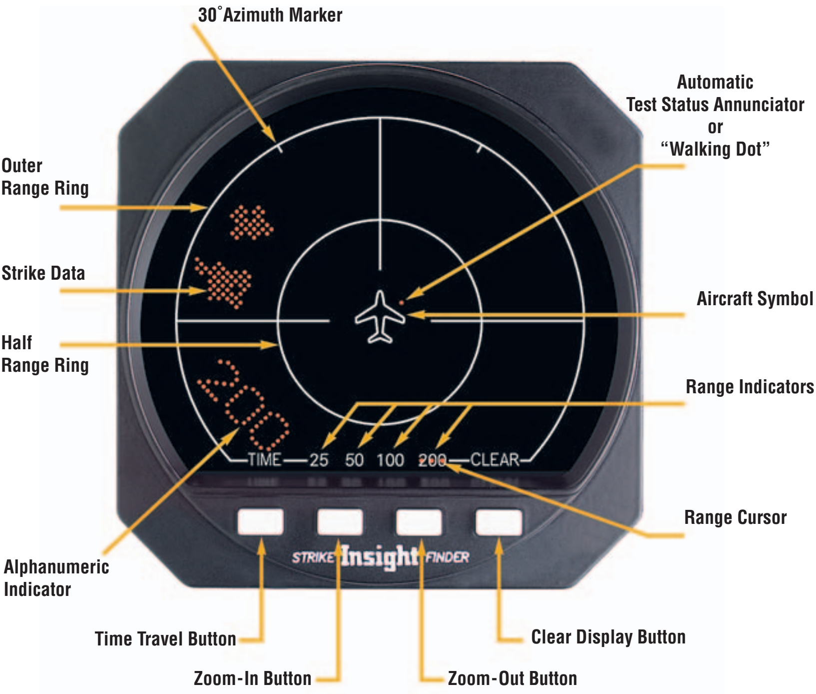


Figure 4. Display Overview of Controls and Indicators

30-degree Azimuth Marker — helps with identifying the location of thunderstorms relative to the aircraft's intended track.

Outer Range Ring — is the outer boundary of viewable strike data within the selected range. (ex: 200 nm, 100 nm, 50 nm, 25 nm)

Half Range Ring — is half the distance from the aircraft to the outer range ring, for the selected range.

Strike Data — is plotted on the display as bright orange dots to indicate the location, range and severity of detected lightning activity.

Range Indicators — are used to show the current viewing range selected. They indicate the distance from the aircraft to the outer range ring.

Range Cursor — highlights one of the four range indicators to show selected range view, (defaults to 200 nm).

Alphanumeric Indicator — appears as large digits in the lower left quadrant of the display. Provides readout of range selection, Time Travel function and troubleshooting codes.

Aircraft Symbol — represents your aircraft. You are here.

Ultra Bright LED or Gas Plasma Display — consists of a 2.5-inch diameter viewable area. It displays strike data and status messages with bright orange dots against a black background.

Automatic Test Status Annunciator — appears in the center of the display as a **"Walking Dot"**, which moves in a clockwise direction. The presence of this dot means the Strike Finder has successfully passed all automatic diagnostic tests.

Zoom-In/Zoom-Out Buttons — permit the operator to step through the range selections (25-50-100 & 200 nm), smoothly altering the distances viewed on the display.

Time Travel Buttons — allows the pilot to display recent **strike data history** — compressing about one hour of storm activity into a one minute presentation.

Clear Display Button — clears the display of all dots but does not erase the strike data history employed by the Time Travel function.

OPERATING PROCEDURES

Strike Finder is easy to use. Only four buttons control all of its functions because many features are automatic. Perform a **pre-flight check** of all the Strike Finder functions to obtain a working knowledge of the operating procedures, *before you need them in flight*.

The operating procedures are explained from the initial boot-up, through all the operator controls, concluding with special functions.

Automatic System Boot-Up

Strike Finder automatically starts when the avionics master switch is turned on. The Strike Finder system will begin a software boot-up, and a display self test procedure. **Display test** consists of a series of three **sunburst patterns** emanating from the center and expanding to the **Outer Range Ring** of the display. This sunburst pattern ensures that all **Display pixels** (dots) are lighting correctly. Following this, the software version number is displayed briefly in the lower left quadrant of the display.

On start-up Strike Finder automatically selects the 200 nm range view. This ensures that distant weather is depicted, and not inadvertently ignored with a shorter range selection.

Automatic Test Status Annunciator

Once the boot-up procedure is completed, the Strike Finder System automatically carries out a self-diagnostic system test every minute. A successful test is annunciated by the **Test Status Annunciator** in the center of the display. The Test Status Annunciator or **"Walking Dot"** rotates clockwise in the four positions *(as shown in Figure 5)*, to affirm the successful completion of each test. So long as the Test Status Annunciator is present, you can be confident of Strike Finder's weather depiction capabilities.

Strike Finder performs this system test by sending a very small, precise, test-pulse (imitating lightning **strike data**) from the Display through the shielded harness to the mounted Sensor. Within the sensor, the test-pulse is received by two **loop-type antennas**, and a **sense antenna**. The antenna signals are amplified, and then sent back to the display, where they are digitally analyzed for proper system function and accuracy.

Figure 5. Display Showing Automatic Test Status Annunciator

Fault Detection

If a fault is detected, the appropriate error code is displayed in the lower left corner of the display *(see Troubleshooting section for error code descriptions, p.52)*, and the test rate is increased to once per second. Also, the "**Walking Dot**" disappears from the display. A persistent error code indicates a permanent failure.

A **temporary fault** is annunciated by the momentary display of an error code. This kind of fault is most commonly caused by momentary electrical interference. When the code is no longer displayed and the **Test Status Annunciator** has returned to normal, one can assume the unit is functioning normally. For troubleshooting purposes, it is helpful to take note of any error codes that appear.

Zoom

Figure 6. Zoom Buttons

Zoom-In/Zoom-Out

Strike Finder is capable of 25, 50, 100 and 200 nm range views. The two center buttons control display zoom *(see Figure 6)*. Depressing the **Zoom-Out** button increases the range setting. Depressing the **Zoom-In** button reduces the view of the display to the next shorter range. A display of shorter range provides a magnified and more detailed picture of storm activity. As the aircraft approaches an area of thunderstorm activity you may elect to zoom in for a better depiction. **Note**, regardless of the range view selected, Strike Finder is always detecting lightning out to 200 nm!

Zoom Indicator

With this innovative (and patented) feature, you can zoom through the four range selections, smoothly altering the range view, and a numeric readout **Zoom Indicator** in the lower left quadrant of the display. The Zoom Indicator persists for a few seconds, and then is erased. The **Range Cursor** continuously highlights one of the four range indicators, showing which range view is currently selected.

Zoom Limits

When Strike Finder is fully zoomed in to a 25 nm range view, the **Zoom-In** button has no effect other than to display the **Zoom Indicator**. Similarly, the **Zoom out** button has no affect on the display when 200 nm range view is already selected.

Time Travel

Figure 6-A. Time Travel Button

Why Time Travel?

The left button activates **Time Travel** *(see Figure 6-A).* Time Travel allows you to view an accelerated replay of accumulated thunderstorm activity stored in memory. Like time-lapse photography, it compresses the last 4000 strikes, or up to one hour of storm activity, into a one minute presentation. This is useful for identifying weather areas that otherwise might not be obvious because of random strikes. It also paints a dynamic picture of thunderstorm life-cycle and movement. Time Travel amplifies indications that may be slow, vague and unrecognized in real time perspective.

Starting Time Travel

When suitable storm history data is available, depressing the **Time Travel** button will start the time-lapse presentation. The **Test Status Annunciator** indicates Time Travel mode by reversing direction and doubling its rate of rotation around the aircraft symbol. Simultaneously, the **Alphanumeric Indicator**, in the lower left quadrant of the display, indicates the span of the **strike data history** in minutes. For example, the display of the number 30 indicates that the Time Travel depiction begins with storm activity that occurred 30 minutes previous. After several seconds this time indication is erased from the display.

During Time Travel

At any time during the replay you may depress the **Time Travel** button to determine your position in the data history. For example, a second pressing of the Time Travel button may display the number 20 which indicates that the activity currently displayed actually occurred 20 minutes previous.

Resuming Normal Operation

Normal operation can be resumed in two ways:

1) **Automatic**—Strike Finder will automatically resume normal operation upon completion of data replay.

2) **Manual**—At any time during data replay, operator can manually return to normal operation by pressing and holding in the **Time Travel** button, then press the clear button and release both together.

Clear Display

Figure 7. Clear Display Button

The **Clear Display** button clears the display of all strike dots, but does not erase any strike data history employed by the **Time Travel** function, *(see Figure 7)*. Strike Finder will immediately plot new lightning activity on the display.

Evaluating Dot Accumulation

Clearing the display at any time, also permits evaluating the rate of dot accumulation as an indicator of storm activity and severity. Strong thunderstorm activity is shown by rapid accumulation and large cluster size. **Strike data** will appear more slowly, with small clusters, in a dissipating storm.

Special Functions

Dealer Mode

Figure 8. Dealer Mode Buttons

Installation or Service Procedure

The **Dealer Mode** function is used only by a qualified technician to verify correct operation during installation, or servicing *(see Figure 8)*.

Starting Dealer Mode

Dealer Mode function is activated by pressing and holding in all four control buttons for two seconds until the "**sunburst**" sequence begins. After a sequence of five "sunbursts", the display will show two circles of test dots (8 dots on the inner circle, 6 dots on the outer circle). The dots are spaced at 45-degree angular intervals, and include the four cardinal points. The outer circle of dots must be located halfway between the inner and outer range rings. The inner circle of dots encompasses the "**walking dot**", near the center of the display. Using the "**Zoom in**" and "**Zoom out**" buttons to change ranges, ensure that these dot circles are repeated on each of the 50, 100, 200 nm ranges. The dots zoom off scale on the 25 nm range. With dot circles plotted on the display, and aircraft gyro compass operating, bearing correction can be checked by rotating the aircraft, or the compass. The dot circle must rotate in the opposite direction to that of the plane, and by an equal amount.

Exiting Dealer Mode

The Display may be returned to normal operation by pressing the two right buttons *(see System Reset for details, p.15)*.

System Reset

Figure 9. System Reset Buttons

What Is System Reset?

System Reset function is activated by depressing and holding the two right buttons for a few seconds and then releasing *(see Figure 9)*. System Reset will return the display to normal operation after the use of **Dealer Mode**. It will also activate the **sunburst pattern** to check that all **Display pixels** (dots) are lighting correctly. Also, the software version number in the lower left quadrant of the display can be verified, for discussions with technical support.

USING STRIKE FINDER

Introduction

Effective and safe use of Strike Finder as a weather avoidance technology is predicated on a knowledge of thunderstorms and their hazards. A mere understanding of the features and functions of Strike Finder is not enough to ensure safe piloting. Anyone who endeavors to fly in regions of severe weather must have a thorough understanding of thunderstorms, their characteristics and hazards *(see Weather Avoidance Concepts, p.39)*.

Flight Planning

Before embarking on any flight, careful preparation and planning should be done.

- Select a route that will take into consideration the landscape of the country to be flown over, refueling stops, emergency landing areas, prohibited areas, etc., all of which are factors that will help you to select a good route.
- Obtain a weather briefing from Flight Services to help you plan a safe flight. They will give you information about prevailing weather conditions, and forecasts of expected weather developments.

Course Selection

Over, under, around or through? You need to understand when and how a particular weather condition could become hazardous, and plan alternate action. Study a weather map and plan a route that offers a good avoidance path.

A thunderstorm is a weather phenomenon that creates serious hazards to aircraft. The NTSB findings, as reported by the AOPA Air Safety Foundation study (General Aviation Weather Accidents), reports that **thunderstorm weather-related accidents are 66% fatal. In the case of light airplane pilots, the best advise on how to fly through a thunderstorm is simple—DON'T.**

Flying Over

High altitude encounters with storms present unique hazards. First, the possibility of ice, compounded by the marginal performance, at altitude, of both the aircraft and some de-ice equipment. Second, the loss of navigation and communication capability to heavy **P-static**. Third, the likelihood of lightning strikes in the ice crystal overhang area of most storms. Some storms are so tall that all aircraft must circumnavigate them.

Flying Under

Flying under storms is tempting at times. Even severe storms can lure the unsuspecting pilot with a seemingly bright clear path underneath. LOOK OUT! What looks harmless is actually the inflow path of the storm. It can ingest an aircraft of any size. Even with gear and flaps down and engine power at idle the VSI will peg and the altimeter needle will exceed prop RPM. A 180-degree turn may be the only escape. Flying under weather is advisable only in conditions of mild stratiform rain.

Flying Around

Flying around storms is the safest and most common practice. Providing adequate margins are available, and used, it is a safe procedure. Avoid situations in mountainous terrain where the minimum safe altitude exceeds the performance of your aircraft. Include extra fuel when flight planning a trip where deviations are likely.

Display Interpretation

Think of your Strike Finder as a 360˚ weather window, with a viewing distance of up to 200 nm from your aircraft. Lightning activity is illuminated on the Display as bright orange dots.

Long Range View

In the 100 and 200 nm views, the Strike Finder system will plot one strike dot on the display for each lightning strike detected. If Strike Finder detects increased lightning activity in the same area, the number of **strike dots** displayed will increase in number and start to form **strike data cells** (clusters). One-to-three dots warn about hazards in developing conditions, although a dozen or more are typical. These **cells** are a clear indication of an increased lightning activity. As these cells grow in size, and become more defined, more avoidance margin should be accorded.

Short Range View

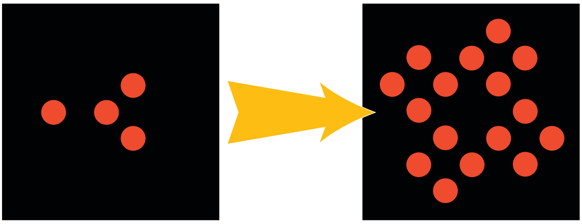
In the 25 or 50 nm range view, Strike Finder plots each lightning strike as four dots. This accentuates the displayed data so as to draw more attention to it at short ranges. This is apparent when zooming from 200 or 100 nm to the 50 or 25 nm—one dot becomes four dots. Likewise, a small cell becomes a much larger cell. Typically, if a cell in the 200 nm range view has 4 dots it will have 16 dots after you zoom to the 25 or 50 nm range view.

Factoring Zoom

Figure 10-A and 10-B shows the transformation of a single dot and a small cell when **zoomed** to 50 or 25 nm range views. When zooming, to see independent **strike dots** and **strike data cells** at a shorter range view, the Strike Finder system displays them in an enhanced manner. For example, when zoomed to 50 or 25 nm range view, a single dot will transform to four dots. Similarly, a small cluster will increase its number of dots by a factor of four, and become a much larger cluster, which is easier to see.

Single dot in the 100 or 200 nm view, Zoomed to 50 or 25 nm transforms to four strike dots.

Figure 10-A. Single Dot Zoomed In

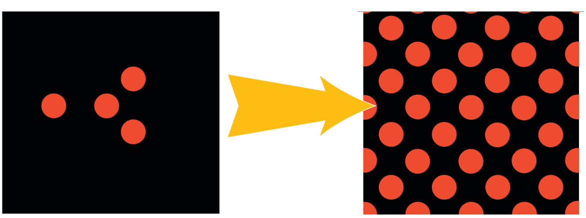


Cluster of four independent dots in the 100 or 200 nm range view, Zoomed to 50 or 25 nm transforms to sixteen strike dots.

Figure 10-B. Cell Zoomed In

Strike Finder plots a single **strike dot** in the 100 or 200 nm range view, depicting an area of 100 sq miles where lightning activity is detected. Multiple lightning strikes detected in this same area may only plot as one dot. Therefore, under severe conditions, when lightning activity is concentrated in small areas, there will be more than one strike per displayed dot while in the long range settings. When **zoomed** in to 50 or 25 nm, Strike Finder will display more than four dots as shown in *Figure 11.* In fact, under severe conditions, four or more dots are common.

Single dot in the 100 or 200 nm range view, comprised of multiple lighting strikes zoomed to 50 or 25 nm, transforms to more than four strike dots.



Cluster of four independent dots in the 100 or 200 nm range view, comprised of multiple lighting strikes, transforms to many dots when zoomed to 50 or 25 nm, and in this example, appears to fill the viewing area.

Figure 11. Single Dot and Cell, Comprised of Multiple Strikes

Display Zoom Interpretation

Zooming Strike Finder to a shorter range view decreases the size of area shown on the display. The process is the same as zooming with a camera. Magnification is obtained at the expense of field-of-view. The four map examples *Figure 13-16 (p.19-20)*, demonstrate the **Zoom** feature, to show the relationship of viewable area between the four range views, and the effect Zoom has on **strike dots**.

Figure 13 shows the Strike Finder display in the 200 nm range view. Three strike areas are plotted, a small cluster at 11:00, another at 1:00 and a single strike dot at 4:00.

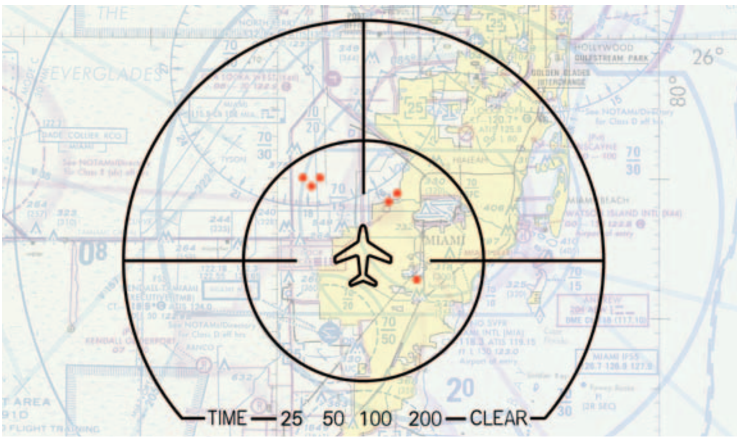


Figure 13. Display at 200 nm Range View (125,000 sq. miles)

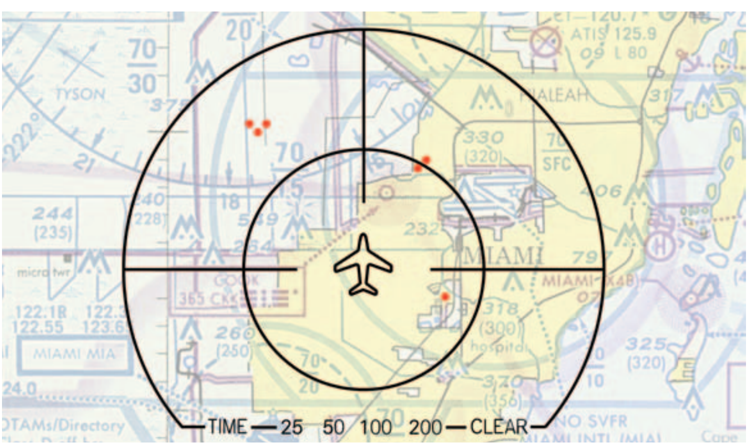


Figure 14. Zoomed to 100 nm Range View (31,000 sq. miles)

Figures 14-16 shows the display zoomed from 200 nm through to 25 nm range view. The viewable area is reduced by one-quarter each time the zoom buttons are depressed, resulting in less area being displayed. Range and bearing of the **strike dots** is maintained relative to the aircraft, through all range settings, as shown by the outward movement of the strike dots. When zoomed to 50 or 25 nm range view *(Figure 15 and 16)* the strikes are displayed by a four dot cluster, *(see Factoring Zoom for additional information, p.17)*.

Note: Images are **Not** to scale and are **Not** to be used for navigation.

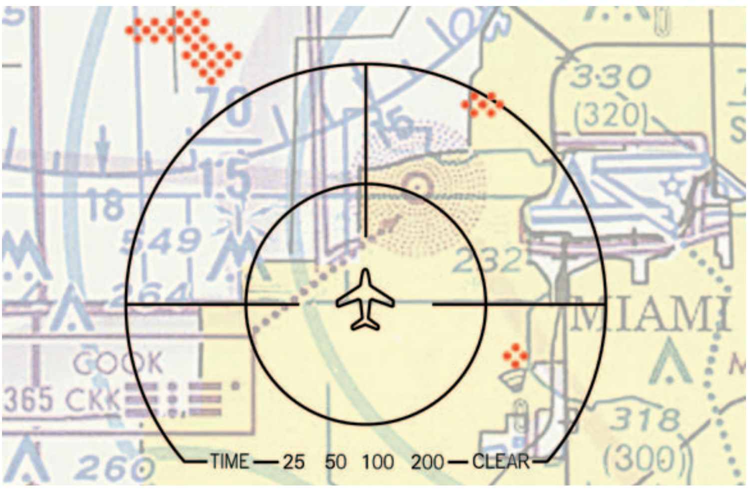


Figure 15. Zoomed to 50 nm Range view (8,000 sq. miles)

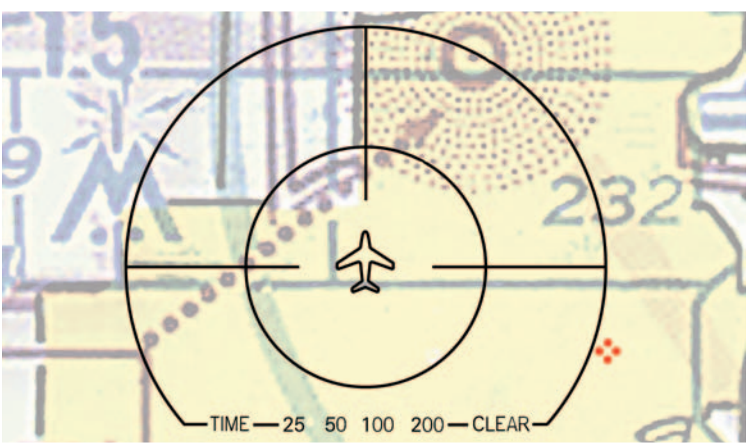


Figure 16. Zoomed to 25 nm Range View (2,000 sq. miles)

Caution and Danger Areas

Figure 17 shows two special areas; *yellow* for CAUTION and *red* for DANGER. Storm activity in these areas is of particular concern, because it lies on or adjacent to the aircraft's flight path. Severe weather associated with the thunderstorm can extend considerable distances from the lightning discharge.

Long Range 200 nm **100 nm**

When the display is **zoomed** to the short range settings 25 or 50 nm, the DANGER area expands. In the 25 nm range view the DANGER area fills the entire display. Storms plotted while in this range are considered too close for safe flight.

Short Range 50 nm **25 nm**

Figure 17. CAUTION and DANGER Areas

Note: these colored areas, as graphically shown, do not and will not appear on your Strike Finder. They are shown here to emphasize the importance of storm activity in these areas.

Caution Area

Lightning activity plotted within the yellow CAUTION area, should be viewed as possible hazardous activity. Keep a close watch on this activity. Monitor the strike cell development for signs of increased size and intensity as you continue to navigate closer to the **cells**. Continue monitoring your situation and start to develop a plan for a possible flight path deviation around the storm—PLAN AHEAD!

For a more defined and revealing view you may **zoom t**o a short range setting. **Note:** on short range view, storm cells will appear larger with many more dots, and the Danger area will extend to the **Outer Range Ring**, *(see Figure 17, p.21)*.

Danger Area

Lightning activity plotted within the red DANGER area **30-degree azimuth**, left or right of your flight path, should be thought of as dangerous activity. You must divert from your present heading to a heading that will allow you to safely circumnavigate the storm. To achieve a safe flight path, you should look for clear areas outside the DANGER area and turn toward a clear area free of **strike dots**., *(see Planning To Deviate, p. 27, for details).*

Knowing how to interpret the display, for bearing, range and storm severity, is only part of the equation when using Strike Finder as an avoidance device. Heading and track must also be considered.

Effect of Wind Drift

All forms of weather detection devices including **Radar**, are effected by wind drift. When flying in cross wind conditions, the airplane's track and heading will differ. The amount they differ is dependent on the direction and magnitude of the cross wind component, *(see Table 1)*.

Table 1 lists some examples of **Wind Drift** angle (the angle between the heading and the track) caused by cross wind. Because wind speed and direction vary, monitor the amount and direction of wind drift for interpretation of Strike Finder display, and deviation planning.

Cross Wind Component / Airspeed	10 kts	25 kts	50 kts	100 kts
100 kts	6°	14°	27°	45°
200 kts	3°	7°	14°	27°
300 kts	2°	5°	9°	18°

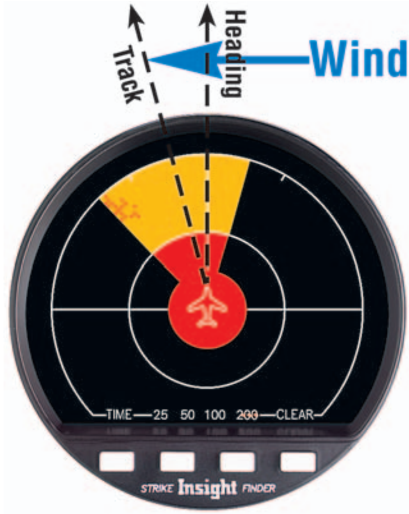
Table 1. Wind Drift Table

Note: Storms may or may not be experiencing the same wind drift as the aircraft. (For example, Frontal Thunderstorms are influenced by two different air masses with an associated frontal wind shift).

With Light or No Wind

Figure 18, (p.324, shows the Strike Finder CAUTION and DANGER areas and the effect of a strong cross wind on a 200 kt aircraft. One active thunderstorm appears as a small cluster at 10:30 about 150 nm from the aircraft. With a light cross wind condition, the track of the aircraft is basically the same as the aircraft heading. The CAUTION and DANGER areas are measured within the two **30-degree azimuth markers** and the thunderstorm cluster appears outside the CAUTION area.

Light Winds
No Drift



50 kt Cross Wind Component
= 14˚ Drift

Figure 18. Effect of Cross Wind

With Strong Cross Wind

With a 50 kt cross wind, a 200 kt aircraft has a drift angle of 14-degrees. The CAUTION and DANGER areas have shifted. The cluster of **strike dots** is now positioned within the CAUTION area. Monitor the situation and start to plan a deviation.

ASSESSING STORM SEVERITY

Introduction

How does one identify a severe storm? Is a single orange dot a storm? What does a real threat look like?

The Strike Finder system shows the relative amount of lightning activity within the thunderstorm cells. Pay close attention to the strike **dot accumulation rate** as a location and severity indicator of storm activity.

Severity Indicators

Your first clues to severity should come from your weather briefing. It will give you the probabilities for severe conditions. Once airborne, you need to augment forecast information with real data. Strike Finder provides six basic indicators of storm severity.

1) **Cluster Size**—The Strike Finder's precise depictions utilize fewer dots for equivalent storms. As few as 3 dots will warn you of a potential hazard, although a dozen or more are typical. Dot density is a good clue to storm severity. When a cluster fills in solid, give the storm extra avoidance margin.

2) **Accumulation Rate**—The rate of dot accumulation is a good measure of storm severity. A few dots per minute suggests mild conditions. A dot per second should be labeled "moderate". Two dots per second is "severe" strike activity. Over periods of many minutes, the accumulation is more vivid in the **Time Travel** mode, *(see p. 12 for details).*

3) **Adjacent Activity**—Strike Finder is sensitive to adjacent activity. When cells are numerous, they absorb one another, coalesce into larger cells, and quickly fill spaces between themselves. Dots marching from one cell to another indicate severity of the cells and a dangerous area between them.

4) **Storm Persistence**—Strike Finder strike dots have a persistence or dot longevity, of five minutes. For severe storms, dots remain in the same location for much longer than five minutes. If in doubt, use the **Clear Function** and observe the reaccumulation.

5) **Size Versus Distance**—Strike Finder size-vs-distance display closely follows a radar guideline: Events appearing large at significant distance are monstrous when nearby. Remember also that three dots at a 100 mile distance will become 12 dots when the range is shortened.

6) **Cluster Fragmentation**—Strike Finder sensitivity may generate cluster fragmentation, or a widely scattered array. This alerts you to a wide spread and churning convective area where simply avoiding one dot or cluster may not produce a smooth ride. When the entire area is unstable, the mixing mass can produce a multitude of minor strikes in a polka-dot effect.

Strike Dot Interpretation

A strike dot depicts a square area where lighting is detected, in relation to the selected range. This square area can cover a large or small area, dependent on the range selected. For example, *Figure 19, (p.26),* shows **strike dots** in the 200 nm range view, depicting an area of 100 sq. miles.

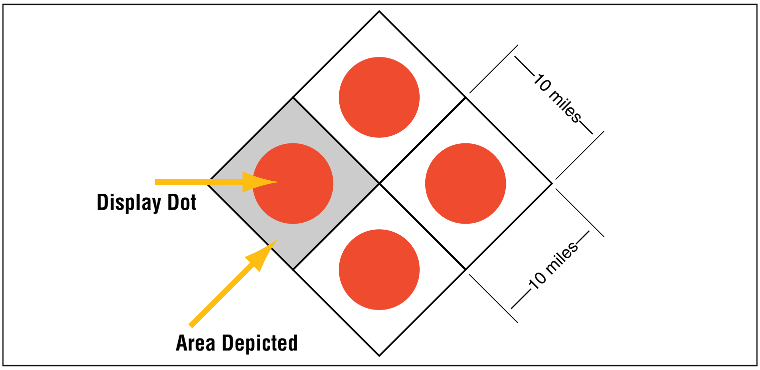


Figure 19. Area Depicted by Strike Dot on 200 nm Range View

Convective weather over these areas can often produce more than one lighting strike. In fact, several lightning strikes concentrated in small areas are common under severe conditions. Multiple strikes concentrated in the area depicted can appear to overlap and plot as one dot. Remember, in the 100 or 200 nm range Strike Finder will plot one visible dot per the square area depicted, no matter the number of actual strikes detected. Therefore, when viewing a dot, be aware there could be more than one lightning strike.

In areas of increased lightning activity, Strike Finder will plot independent **strike dots** near each other, and start to form **cells** (clusters). As the number of lightning strikes detected increases, so does the **cell size**. Therefore, cell size is directly related to the severity of hazardous activity within thunderstorms. To assess developing thunderstorms, **zoom** to short range for a better depiction.

Range Interpretation

As Strike Finder is **zoomed** to shorter view ranges, the square area depicted decreases in size. In *Figure 20, (p.27)*, enlarged strike dots are used to show how the area depicted decreases in size and the dots move closer together as Strike Finder is zoomed through the four ranges. For example, the square area depicted, decreases from 100 sq. miles at the 200 nm range view, to 1.56 sq. miles at the 25 nm range view. Therefore, two strike dots plotted side by side will also be closer.

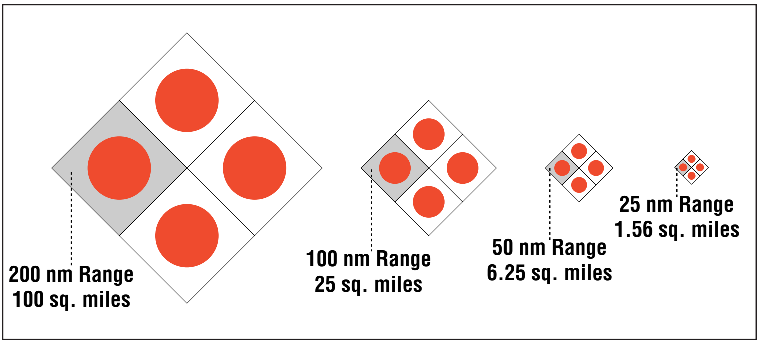


Figure 20. Strike Dots Zoomed Through the Four Ranges Views

Planning To Deviate

If your Strike Finder detects thunderstorms close to your intended flight path, a deviation from your present course **must** be initiated. Observe the Strike Finder closely, to determine the distance and bearing of the thunderstorm from the aircraft.

Avoidance By Angle

The FAA Advisory Circular, Subject: Thunderstorms, recommends that you “avoid by at least 20 miles any thunderstorm identified as severe or giving an intense radar echo”. Pilots have no direct control over distance but do have complete control of heading. Correct heading selection will provide the “required storm avoidance angle”, needed to keep the aircraft a safe distance from any storm activity.

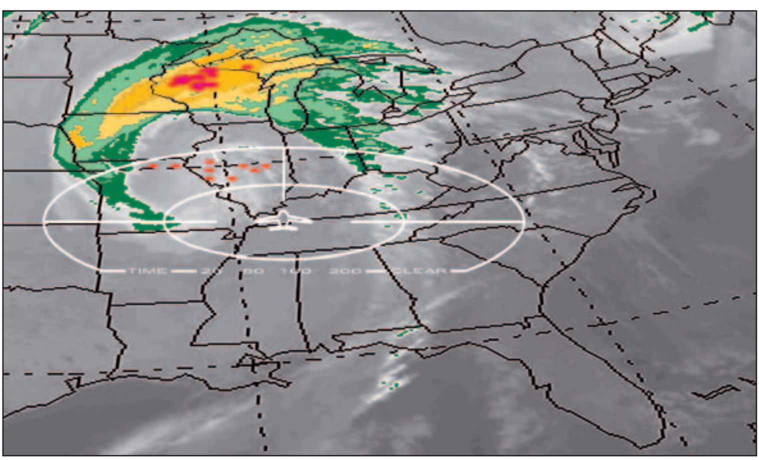


Figure 21. Weather satellite View with Strike Finder Display Area

Figure 21 (p.27), shows a typical storm system likely to be encountered while in-flight. The presence of storm activity on the display raises the following questions:

1) How close is the storm to your plane?

2) Are you going to miss the storm on your current heading?

3) How much should you turn to deviate?

One-Quarter Rule

Strike Finder has a unique feature called the One-Quarter Rule that is used to determine the "required storm avoidance angle". The following section, explains and demonstrates, how the One-Quarter Rule is used.

Storms at the **Half Range Ring**, 30-degrees from the aircraft's intended track, will have an avoidance distance of one quarter of the Display range. For example, *Figure 22* shows the Strike Finder display in the 200 nm range view. Using this knowledge, in conjunction with the One-Quarter Rule, the distance at 30-degrees can be interpreted as being 50 nm or one-quarter of 200 nm, *(see Table 2 for One-Quarter Rule distances and "required storm avoidance angle" for all range view settings, p.29).*

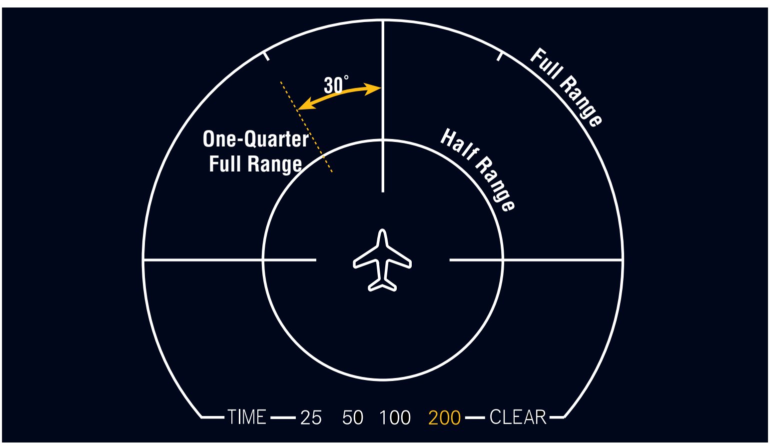


Figure 22. One-Quarter Rule Display

Range Selection	Distance at Half Range Ring 30° from Projected Track	Required Storm Avoidance Angle
200 nm	50 nm	0°
100 nm	25 nm	0-40°
50 nm	12.5 nm	30-90°
25 nm	6.25 nm	90-180°

Table 2. One-Quarter Rule Table

Rule-Of-Thumb

A good rule-of-thumb, is to **avoid all storms in the 100 nm range view by 30-degrees**. In addition, an extra 10-degrees is advisable for added safety. This range setting and angle will position the aircraft approximately 40 miles from the storm, thereby providing a better margin of safety. A storm encountered on the 100 nm range view, that has a 30-degree avoidance angle from the intended track, is considered to be at a safe distance. Use this range setting when planning a deviation around thunderstorms.

Storms in the 25 nm range view are too close. The "required storm avoidance angle" is much greater than at the 100 nm range view. (See Table 2). For safety reasons, do not use the 25 nm range view for deviation planning.

Compensate For Wind Drift

When flying in cross wind conditions, the avoidance angle is affected because the airplane's track and heading are different. *Figure 23 A-B (p.30)*, illustrates conditions likely in the case of air mass thunderstorms.

Drift Near Air Mass Thunderstorms

In the example shown in *Figure 23-A* (p.30), a cross wind blowing the plane away from the storm, has increased the avoidance distance or angle from 30-degrees to 44-degrees. The aircraft may safely navigate past the thunderstorm.

The amount of increased distance as a result of a cross wind component will vary based on wind speed and direction. The increased distance, may or may not permit the aircraft to pass a thunderstorm at a safe distance. Monitor each thunderstorm associated with a cross wind component and adjust heading accordingly to facilitate a safe deviation around thunderstorms.

In the example shown in *Figure 23-B*, a 50 kt cross wind drifting the plane toward the storm, has decreased the avoidance distance or angle from 30-degrees to 16-degrees. The pilot should compensate for drift with additional crabbing (turning into the wind). The degree of crabbing will vary based on several factors, *(see Table 1 (p.23) and Table 2 (p.29), also Effect of Wind Drift section, for further details).*

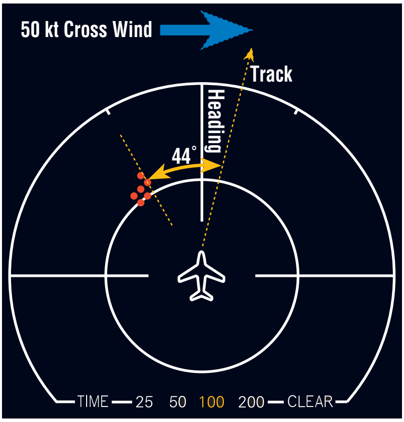


Figure 23-A

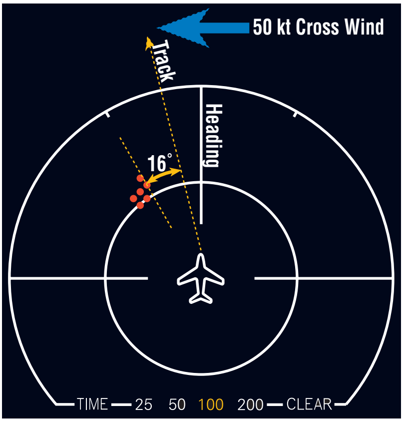


Figure 23-B

Cross Wind Effect On Avoidance Angle

Drift Near Frontal Thunderstorms

Flying toward frontal activity poses special problems. Unlike air mass weather where similar wind conditions may exist for hundreds of miles, frontal conditions almost always include a significant wind shift.

The variable nature of fronts and the wide range of conditions encountered there dictate careful pre-flight planning and cautious in-flight procedures.

Numerous, powerful storms associated with fronts, may make wind conditions unpredictable. A line of frontal storms (squall-line) may be impassible; give them a wide berth.

Estimating Distances From Strike Dots

Figure 24-A (p.31) shows the display at 200 nm range view. Using this knowledge and the One-Quarter Rule, the strike dot at half range can be calculated to be approximately 50 nm from the projected track. No deviation is required. *Figure 24-B (p.31)* shows the display at 50 nm range view. **Strike dots** plotted at the same place, are approximately 12.5 nm from the projected track. A deviation of 30 to 90-degrees (dependent on wind drift), is required.

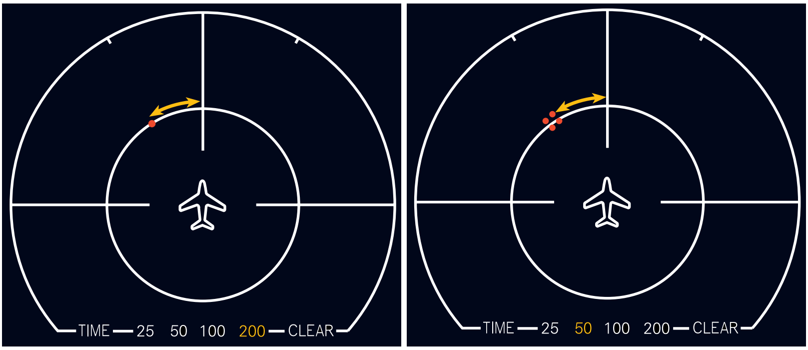


Figure 24-A 200 nm Range View **Figure 24-B 50 nm Range View**
Strike Dot Distance Using One-Quarter Rule

Estimating Distances Between Cells

Figure 25-A shows two cell formations in the 200 nm range view. The cells are calculated to be approximately 50 nm left and right from the projected track, or 100 nm apart. No deviation is required. *Figure 25-B* shows two cell formations in the 50 nm range view. **Strike cells** plotted at the same place, are 12.5 nm left and right from the projected track or 25 nm apart. A deviation around the storms is recommended—not between.

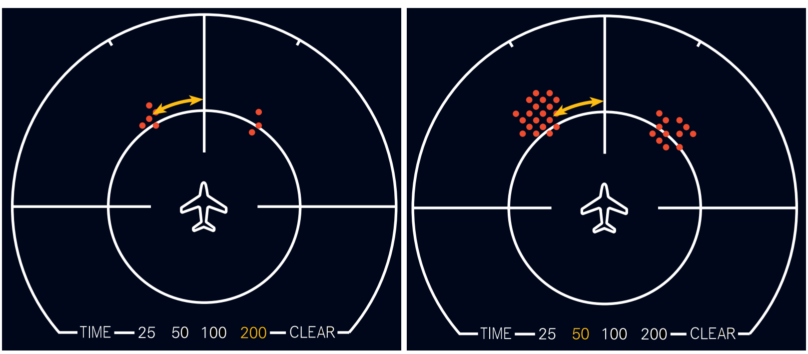


Figure 25-A 200 nm Range View **Figure 25-B 50 nm Range View**
Storm Cell Distance Using One-Quarter Rule

STORM EXAMPLES

Study the following examples to become familiar with the Strike Finder display.

Storm 1

Figure 26. Display set to 200 nm range view showing three storm cells

Description

At 200 nm range view, three areas of activity are shown. **Cells** are 150 nm at 11:00, 12:00 and 1:00 positions. The pilot has typically 30 to 45 minutes warning on the present route. The storms are within the CAUTION area.

ANALYSIS

If they are mature thunderstorms, the two well developed areas may dissipate by the time the aircraft reaches their location. If they are severe or steady-state thunderstorms, they may persist or grow more hazardous.

Also note the scattered strikes between the two large clusters. This may indicate new developing activity or an old cell dissipating. The area between the two clusters is unstable and is a **hazardous** path!

Suggested Action

Use **Time Travel** to observe the history of this activity and start planning a deviation. A left or right turn 45-degrees either side of course provides a clear route, but watch for signs of any more associated storm activity.

Storm 2

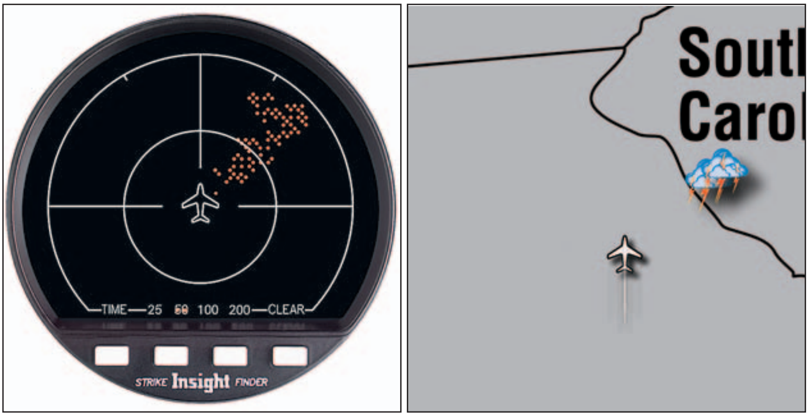


Figure 27. Display set to 50 nm range view showing enhanced view of storm

Description

This display range is set to 50 nm. At this range view, a strike is depicted as a cluster of four dots. There is a linear cluster at 10 nm, 1:30 position.

Analysis

A lengthy and electrically active line of weather is too close to the aircraft. Thunderstorm activity within the DANGER area!

Suggested Action

ZOOM out to the 100 nm range view to:

1) Determine whether this is an isolated cell or part of a larger system.

2) To assure that deviating 30-to-45-degrees to the left provides an activity free route. More distant activity is not visible on the 50 nm range view.

Start deviating with a left turn of 45-degrees. Once you are clear of the cell, the 100 nm or 200 nm range view will allow further route planning.

Cell Stretch

All spheric displays have the property of **cell stretch**—a trailing effect of dots from a storm cell in a radial direction, *(see Figure 28)*. This phenomenon occurs when mapping strong disturbances. The **strike dots** simultaneously trail outward and inward away from a storm **cell.** It is caused when multiple strikes of varying degrees of strength are detected within the same storm cell and plotted in a linear pattern according to their intensity. The amount of cell stretch is dependent upon the severity of the storm—the more severe, the more cell stretch. Nonetheless, sufficient 'normal' strikes will occur for detection of the storm center.

Figure 28. Cell Stretch

In short range views cell stretch might intrude and appear as building cells within the selected range view. **Zoom** to a long range view to detect cell stretch of distant storms.

The trailing **strike dots** in cell stretch do not necessarily show the actual location of the lightning activity. Strike Finder uses elaborate lightning positioning algorithms to alleviate cell stretch. This process reduces the cell stretch pattern, and by that, greatly improves interpretation of storm cell location.

Strike Finder should not exhibit significant cell stretch with every storm. If this occurs, suspect interference from another electronic device on-board the aircraft. *(see Appendix A, Troubleshooting, p.51)*.

Cell Smear

Cell smear is the apparent elongation of a cell in the direction of aircraft movement. This effect is a result of the aircraft's motion relative to the storm, and the persistence of dots plotted on the Strike Finder display. For example, *Figure 29* shows the display depicting a cell at the 3:00 position. As the aircraft moves, the relative position of the cell changes to the 4:00 position. Dot persistence causes strikes at the 3:00 position to remain visible, while new dots are plotted at 4:00.

Figure 29. Cell Smear

Cell smear is most apparent with fast aircraft passing a very active storm at close range.

Smearing has no affect on storm detection and avoidance.

STORM AVOIDANCE MAPPING

Figures 30 through *34 (p.36-38)* portray the route of an aircraft past a line of thunderstorms. These examples will help you to relate the position of **strike dots** on the Strike Finder display to the storm maps.

Long Range Detection

Figure 30 shows the Strike Finder display depicting a line of five thunderstorms. Two large thunderstorms appear about 150 nm and 175 nm away from the aircraft at 10:30 and 9:30 position. A smaller storm appears about 100 nm at 9:30 position. Two additional small thunderstorms appear straight ahead just off the intended track, about 180 nm off the nose of the aircraft at 11:45 and 12:15 position. Aircraft groundspeed is 180 kts.

Figure 30. 200 nm Range View at start of flight

Figure 31. 200 nm range view after aircraft progressed 30 minutes into flight

Progression of Flight Path

Figure 31 (p.36), shows that the Strike Finder system has automatically updated the display as the aircraft has progressed on course. The cells to the left side of the aircraft appear closer, about 90 nm but present no threat based on present heading. The two thunderstorms ahead are now 100 nm from the aircraft on the edge of the DANGER area. Monitor the situation and start to develop a plan for deviation around the thunderstorms.

Planning the Deviation

Figure 32 shows that the thunderstorms repositioned on the display zoomed to the 100 nm range view. The two thunderstorms ahead appear at 11:30 and 12:45, positioned within the DANGER area. The distance between them is about 60 nm. **Zooming** to a closer range will reveal more details about storm severity and allow a more accurate determination of the *"required storm avoidance angle"*.

Figure 32. Zoomed to Range 100 nm Range View

Figure 33. Zoomed to 50 nm View, 20 minutes later

Zoomed to 50 nm Range View

Figure 33 (p.37), shows the display 20 minutes later **zoomed** to the 50 nm range view. The distant thunderstorms are no longer visible. They have zoomed off the display. The two thunderstorms ahead appear larger and better defined. The storms are now 40 nm at 11:00 and 1:00 position. It is clear now that a deviation around the thunderstorms must be initiated.

Deviate Around Thunderstorms

Figure 34 shows the display zoomed back to the 100 nm range The aircraft has initiated a deviation around both thunderstorms. The Strike Finder system has automatically updated the relative position of all strike dots to the aircraft's new heading.

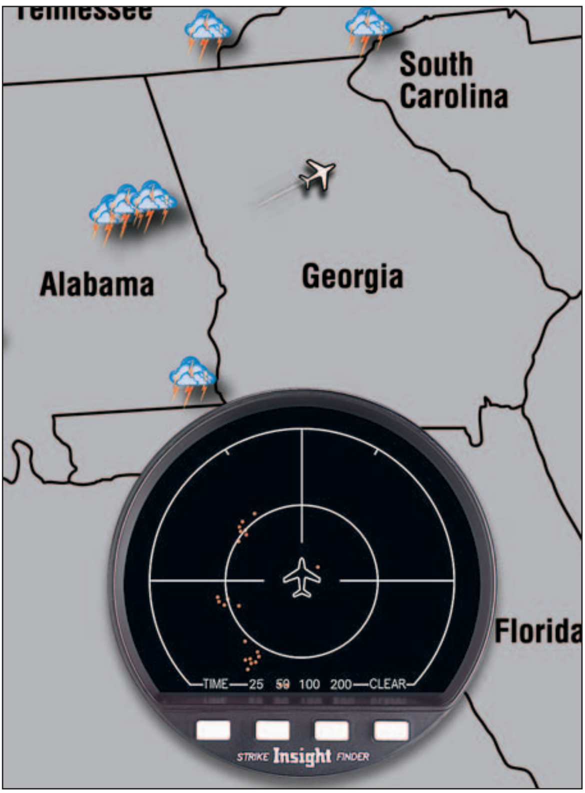


Figure 34. 100 nm Range View, Deviation Around Thunderstorms

WEATHER AVOIDANCE CONCEPTS

WEATHER AVOIDANCE CONCEPTS
HAZARDS ASSOCIATED WITH THUNDER
WEATHER AVOIDANCE SYSTEMS

Weather Avoidance Concepts

The Strike Finder system reliably detects the electrical activity that is present in all thunderstorms, enabling you to avoid lightning, and all the hazards produced by thunderstorms.

When the thunderstorm menace is embedded or hidden by clouds or poor visibility, Strike Finder provides an especially useful picture of the threat. When you can not see, Strike Finder can!

In this section we examine the thunderstorm process and its hazards, and the benefits of Strike Finder technology and Radar.

What Is A Thunderstorm?

A thunderstorm is a cumulonimbus cloud that contains lightning and thunder. Strong wind gusts, heavy rain, lightning, hail and tornadoes are typical hazards produced by thunderstorms. They usually exist for only a short time, rarely over two hours for a single storm.

The National Weather Service definition of a thunderstorm includes: "accompanied by thunder and lightning"! It must produce lightning to be labeled a thunderstorm. It must be electrically active. Lightning is always present, in and near, a thunderstorm.

Thunderstorm Process

Thunderstorm development requires three elements:

1) Moisture

2) Lifting Agent

3) Instability

A cumulus cloud forms when moist air is lifted by a thermal, frontal, or orographic process. If the atmosphere is unstable, the lifted air mass will continue to rise and develop into a thunderstorm cell *(see Figure 35, p.41)*. As the building mass soars upwards, moisture condenses and precipitation-induced downdrafts develop. This process creates violent wind shear and turbulence, and lightning within the cell. Precipitation begins to fall from the cloud base, and the thunderstorm is born.

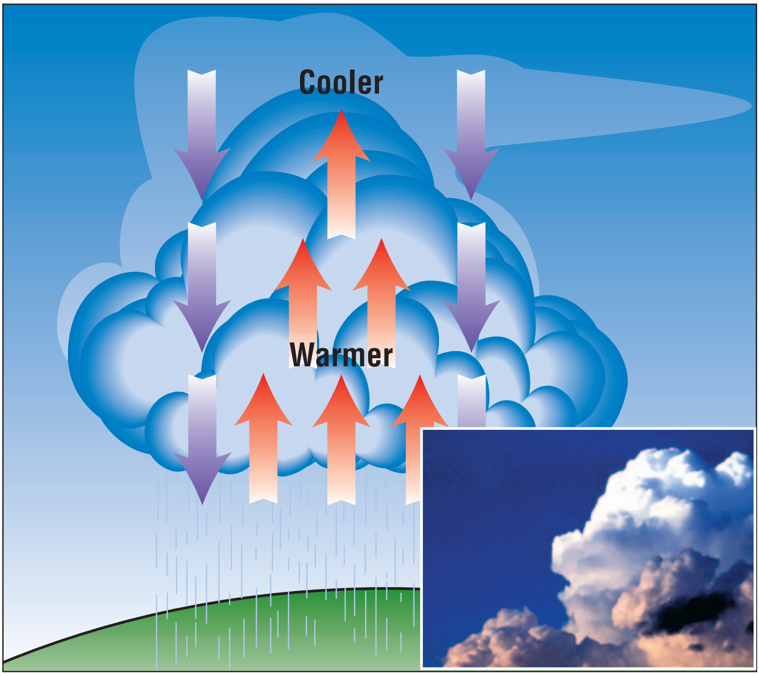


Figure 35. Thunderstorm Development

Thunderstorm Stages

The life cycle of a thunderstorm includes three stages: cumulus, mature, and dissipating.

Cumulus Stage — is the beginning of all thunderstorms. The size of the updraft region (cell) becomes larger and the cloud grows in an unsteady succession of upward bulges, as evident by the thermals that reach to the top. Strong vertical winds, severe turbulence, icing and lightning, are typical hazards that an aircraft could encounter at this stage.

Mature Stage — is reached when the precipitation-induced downdraft reaches the ground. Heavy rain or hail, and in colder areas sleet or snow, are driven by strong downdrafts. Wind shear, lightning and thunder develop as a result of friction between the opposing air currents. At this stage the hazards can be devastating for any aircraft.

Dissipating Stage — is reached when the updraft is overwhelmed by the precipitation induced downdraft. With no source of moisture, the associated hazards decrease and the entire thunderstorm gradually dissipates.

Thunderstorm Types

There are several types of thunderstorms: The air mass thunderstorm, the severe thunderstorm, and squall-line thunderstorm. An air mass thunderstorm consists of one **cell** and lasts less than one hour, whereas the severe thunderstorm is composed of **multicells** or **supercells**, and lasts for up to two hours.

Air Mass Thunderstorm

The Air Mass Thunderstorm grows quickly and is contained within a single cell. At maturation, the thunderstorm is normally self-destructive. Updrafts elevate water. Water accumulates in the upper areas of the storm. When the upward source can no longer support the accumulated water mass, it rains. The rainfall (downward) overwhelms and strangles the lifting process (upward), and the storm dissipates.

Severe Thunderstorm

The Severe Thunderstorm develops when a number of single **cells** interact and produce more cells (**multicells**), thus sustaining the life of the storm. Specifically, the strong updraft tilts and twists moisture into the upper air support. With strong upper atmosphere winds (for example, the Jet Stream,) the storm tilts or leans downwind. This is evident by the highest portion of the cloud spreading outward (downwind), and forming an anvil shape, *(see Figure 36, p.43)*.The water carried upward will accumulate and rain downwind, possibly far ahead of the storm's updraft core. Consequently the mature stage does not initiate the dissipating stage by strangling the updraft element.

A severe thunderstorm has a greater intensity than an air mass thunderstorm. This is evident by the weather it produces: winds of 50 knots or greater, three-quarters of an inch or larger destructive hail, and/or strong tornadoes.

Squall-Line Thunderstorm

Squall line storms are the most disruptive to aviation because they form in lines that can stretch a few hundred miles, and individual storms in the lines can be fierce. Strictly speaking, the lines of storms usually referred to as squall-lines are "pre-frontal squall-lines." Squall lines often trail large areas of stratus clouds with low ceiling and visibility that can linger for hours.

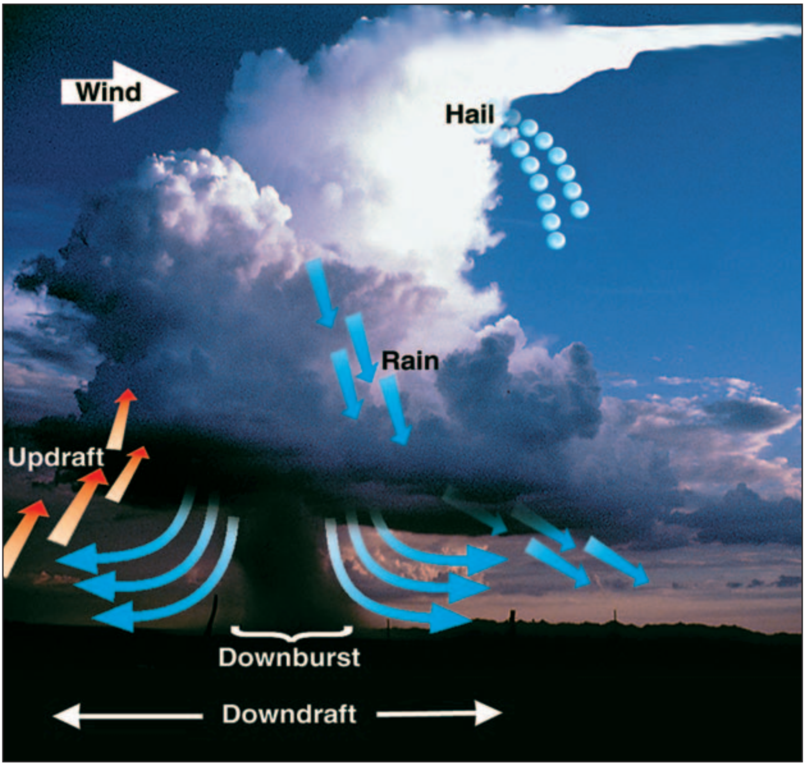


Figure 36. Severe Thunderstorm

HAZARDS WITH THUNDERSTORMS

A thunderstorm contains every conceivable aerial hazard: lightning, catastrophic turbulence, wind shear, severe icing, destructive hail and tornadoes.

Lightning

Lightning is the visible electrical discharge produced by thunderstorms. The convective flow of air currents circulating up and down create friction between the opposing air currents. The friction causes electrical charges within the thunderstorm to separate. Charge separation in the thunderstorm polarizes a region with positive charges at the top, intermediate negative charges within the center, and with positive charges at the base. Since electrical opposites attract, an invisible shadow of negative charges track along the ground beneath the thunderstorm.

This is often oversimplified as positive charges at the upper reaches and negative at the base, *(see Figure 37)*.

Lightning takes place when the positive and negative charge has a voltage difference of about 300,000 volts per foot. Lightning strikes at the speed of light. It may contain up to 200,000 amps of current. With instant air temperature peaks of 50,000˚F along the discharge channel, it is hotter than the sun's surface temperature. The ambient air is exploded into a sonic boom called thunder.

There are three lightning routes: cloud to ground, between the clouds and within the cloud. Most lightning strikes take place within the clouds or between the clouds where aircraft are defenseless targets.

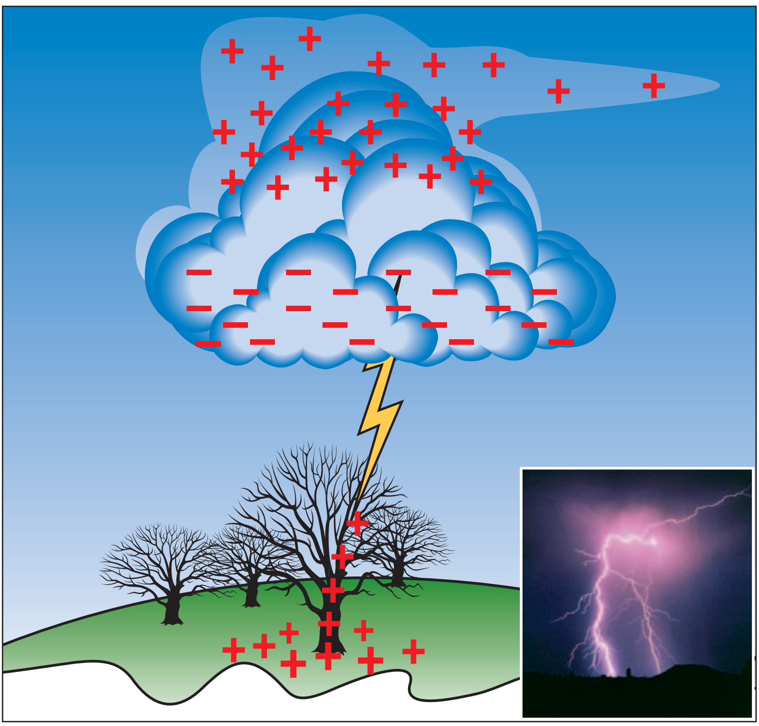
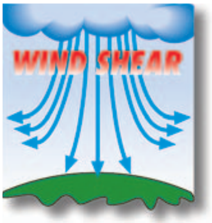


Figure 37. Charge Separation

Downburst

Downburst refers to air coming down from a shower or a thunderstorm, hitting the ground, and spreading out. The violent downburst outflow is typically contained within a 3 mile diameter, although velocities beneath thunderstorms have been measured to travel 18 miles in advance of the thunderstorm itself.

Wind Shear



Wind shear is the sudden "tearing" or "shearing" effect when there is a violent change of wind over a short distance. The change can occur in either speed or direction (horizontal and vertical), or both. Wind shear occurs when a concentrated, severe downdraft from within the thunderstorm, known as a downburst, sends an outward burst of very strong damaging winds toward the ground.

The effect of wind shear on an aircraft can be devastating, especially in low level flight such as taking-off or landing. In these stages of flight the aircraft's performance is severely degraded beyond its capability to compensate.

Tornado

A Tornado is a swirling column of upward flowing air which is found below cumulonimbus clouds, *(see Figure 38)*. Wind speeds of up to 180 kts have been recorded. Tornadoes typically have a diameter of 300 feet to 2,000 feet, although there are reported tornadoes of one mile. They occur typically on the south to southwest side of severe thunderstorms in the midwest. In fact, they occur on the water side, the source of energy. Storms spawning tornadoes must be given the widest avoidance.

Figure 38. Tornado

Hail

Hail is precipitation that falls from thunderstorms as round or irregular balls of ice. The freezing process takes place when water droplets are continuously rotated up and down by air currents within the cell of a thunderstorm. Each time a water droplet is pushed by strong updrafts into the cold upper layers, freezing occurs. The process repeats itself until the weight of the hail stone causes it to fall or the updraft subsides enough to allow hail to fall to the ground.

Be distance aware! Hail has exited thunderstorms from the long cirrus anvil cloud, many miles distant from the storm center. Hail paths 20 miles down-wind are not uncommon. The aircraft in *Figure 39* is a frightening example of damage caused by hail.

Figure 39. Aircraft Damaged by Hail

Airframe Icing

Airframe icing occurs when the aircraft contacts supercooled water droplets within clouds. Airframe ice seriously degrades the performance and control of any airplane. All thunderstorms contain supercooled water droplets and **must** be avoided.

WEATHER AVOIDANCE SYSTEMS

There are two types of on-board storm avoidance systems—lightning detectors and radar. This section will highlight the differences and similarities of the two systems.

Strike Finder System

The Strike Finder system maps lightning. Unlike radar which detects water only, the Strike Finder detects and analyzes the electrical activity (lightning) emanating from thunderstorms. Where lightning is, thunderstorms exist, and so do the other hazards associated with them.

The electromagnetic signals are routinely received by a sensor. Strike Finder uses advanced **Digital Signal Processing** technology to analyze the severity, and bearing, relative to your aircraft. The information is depicted on the Strike Finder display as one cohesive picture of weather mapping.

Strike Finder Advantages

The Strike Finder system and its unique patented processing of lightning signals has some very important advantages over weather radar.

- **Digital Signal Processing** for high fidelity weather modeling.
- High resolution display for detailed weather mapping.
- Identifies thunderstorms before rain starts—radar sees nothing.
- Full-time 360-degree view makes interpretation of both hazards and avoidance paths simple.
- **Zoom control** provides enhanced weather depiction for 200, 100, 50, and 25 nm.
- Works on the ground! You plan your hazard avoidance routes at start-up—on board radar can not.
- Attenuation is NOT a factor! Strike Finder shows ALL the activity, *(see Figure 40, p.48).*

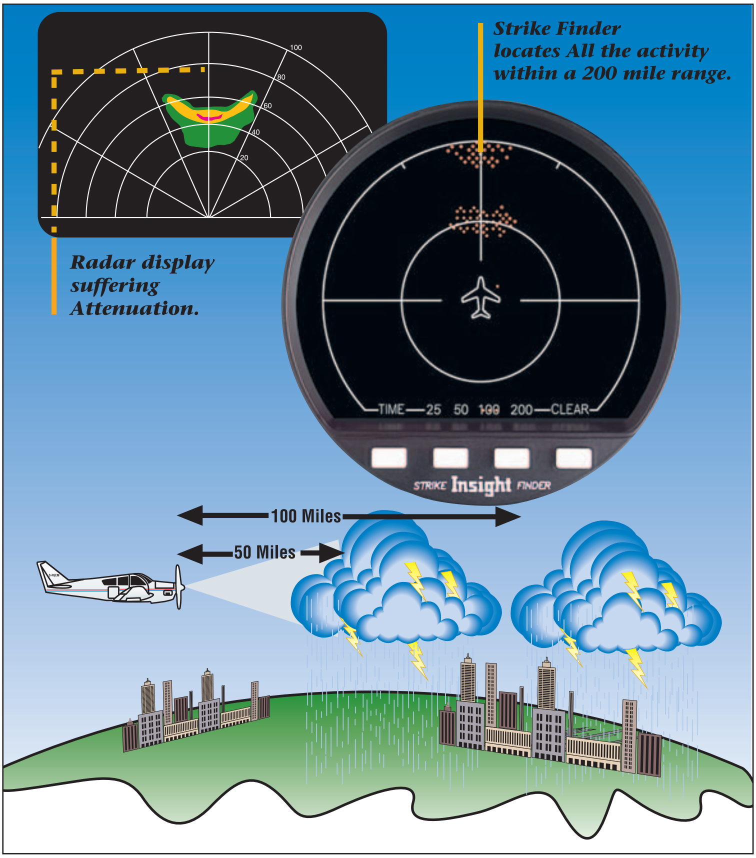


Figure 40. Radar Suffering Attenuation

Weather Radar

The weather radar system sweeps a narrow and highly directional beam of energy, in a lateral arc of 90 or 120-degrees in front of the aircraft. A portion of the beam energy is reflected by the water droplets and returns to the antenna. The precipitation density is measured and then painted on the radar screen as precipitation levels as shown in *Table 3 (p.49)*.

Precipitation Rate Table

As a water detector, radar displays up to four precipitation levels. Three color radars are most prevalent: Green-Yellow-Red. The water value and hazard expectation of each level is shown in Table 3.

Color	Precipitation Rate	Hazard
Green:	.03” to .15” per hour	None
Yellow:	.15” to .5” per hour	Moderate
Red:	.5” to 2.0” per hour	Heavy
Magenta:	Over 2” per hour	Extreme

Table 3. Precipitation Levels

Radar Advantages

Although radar only measures water, it can still be a very useful tool to determine the conditions that lie ahead. For example, if you wish to descend for low level flight or attempt to land, you could use radar to measure the amount of moisture that might be present in low stratus clouds. If cold conditions exist at the loft area of these clouds, the rain could freeze and cause icing. In this case you would choose to circumnavigate the rain mass.

Radar Disadvantages

The most obvious shortfall of radar systems is their inability to measure lightning. Remember, all thunderstorms emit lightning. A force that could be catastrophic to any aircraft.

For example, the Cumulus stage of a thunderstorm is usually rain free and therefore will not appear on weather radar. However, it generally contains lightning which will appear on the Strike Finder display screen, alerting the pilot to its severity and location.

Other inferior features of weather radar compared with Strike Finder are: range, field of view, detection, sensitivity to storm severity and sensitivity to storm height, *(see Table 4 ,p.50, for additional information about the system capabilities of Strike Finder and weather radar.)*

	Strike Finder®	Airborne Radar
Range	200 nm	100 nm
Field of View	360°	90 - 120°
Detects	Lightning	Water
Sensitivity to Storm Severity	Automatic	Manual Gain Controll
Sensitivity to Storm Height	Detects All	Manual Tilt Controll

Table 4. Strike Finder/Radar, Comparison

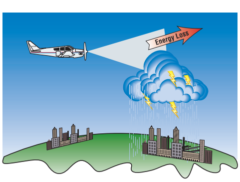
Attenuation

Attenuation is a non-obvious radar problem, created by the very process it uses to measure precipitation density. Moisture in close proximity to the aircraft will scatter the radar beam, thereby depleting the energy return to the radar receiver. The same effect is found with car headlights when driving in heavy fog. The light reflected back off the fog is defused or softened, thereby reducing the visible distance.

This problem, called attenuation affects all radar, meaning heavy rain areas could scatter, or worse, totally block out the radar return from hazardous weather ahead, *(see Figure 40, p.48)*.

A wet windshield means a wet radome. Moisture and ice on the radome will diminish the radar signal. In heavy rain it is not unusual for the energy loss to reduce the reception distance of radar to less than several miles.

Limited Antenna



Radar has a limited field of view. The radar's antenna must be tilted to assure the radar beam is directed into weather, and scans only 60-to-120-degrees of perspective. The effective radar return is about 100 miles. Radar is ineffective before takeoff: The radar **antenna** cannot be elevated to any effective level from the ground, and in-flight radar loses effectiveness as the aircraft descends.

APPENDIX A

Troubleshooting

Strike Finder has three **antennas** inside its sensor. Two are **loop-type** to receive bearing signal data, and the third is a **sense antenna**. The sense antenna is omni-directional, and the phase of its output signal is compared with that of the loops to determine if the strike was on one side of the aircraft or the other. The basic principles are similar to those used in **Fixed-Loop Automatic Direction Finder** (ADF) for bearing detection. Each antenna outputs a signal which is sent to the display unit, where it is digitized and processed for plotting. The loop antenna signals are defined as X and Y, and the sense signal is defined as P.

Strike Finder is basically detecting a radio signal radiated from a vertical electrical discharge (lightning strike), which may be hundreds of miles away. When diagnosing interference problems, it is helpful to consider the fact that a strike with a current of thousands of amperes, hundreds of miles away, may look the same (electrically) as a small spark of minimal amperes a few feet from the sensor. This could be produced by something as simple as bad brushes on an alternator, or a loose wire. Therefore, the location and condition of other electrical equipment and wiring, relative to the sensor, will influence the success of any Strike Finder installation, in terms of electrical interference.

Once the power is turned on, Strike Finder automatically carries out a self-diagnostic test every minute. If a fault is detected, the appropriate error code is displayed in the lower left corner of the display, and the test rate is increased to once per second, *(see Figure 41, p.52.)* Also, the **"walking dot"** disappears from the display. When a fault condition is annunciated in this way, the display may continue to plot strikes, but the data may not be trusted for safe storm avoidance. These are the error codes which may appear : X0, X1, X2,Y0, Y1,Y2, Z, S, B, P.

To assist in diagnosis of fault conditions, the following interpretation of error codes is provided. Reference to Interconnect Diagram 2000-019 in the Strike Finder installation manual.

Diagnostic Error Codes - Interpretation

Figure 41. Diagnostic Codes

X0, X1, or X2 - Continuously Displayed

X channel bandwidth, gain, or phase error. Fault may be in display, sensor, or cable.

Check sensor cable/connector wiring for conductors XA and XB.

Exchange display and sensor with known good components.

X0 - Intermittently Displayed

This code will disappear and re-appear, randomly, and may also disappear after the **CLEAR button** is pressed. It may be accompanied by the plotting of a cluster of dots, a line of dots, a scattering of dots, or no dots at all.

Possible loose connections on cable/connector conductors XA and XB.

In most cases, this error code is the result of repetitive current noise being inductively-coupled into the sensors X and Y loops, at a sufficiently high rate and amplitude to cause interference with the test pulse. This causes the test to fail intermittently. Since X0 is the first test in the series, it is the one that shows up first in a noisy environment. Sometimes however, in normal operation without the presence of interference, a high level of storm activity may cause a momentary X0 error to appear. This an acceptable condition, requiring no operator action.

In order to locate and correct an interference problem, select **Dealer Mode** on the display, and clear the display. Watch the activity number in the lower left corner. This number is a count of the number of times Strike Finder is triggered. The goal of interference investigation is to reduce the rate of triggering (in the absence of real storm activity) to one every 30 seconds, or longer, and to ensure that no dots are being plotted.

If a cluster or line of dots is being plotted, switch off all other electrical equipment in the aircraft, and clear the display. If dots appear again in the same location, rotate the aircraft and again clear the display. If the dots appear at a new location, the interference source is external to the aircraft, and further testing may not be necessary. If the dots appear at the same location, no matter what the aircraft heading, then the source is on the airframe or is being generated by the Strike Finder system itself.

Connect the display to a separate battery, and switch off the aircraft master switch. If dots continue to appear at the same location, the Strike Finder is generating its own dots, and both display and sensor must be returned for repair.

If the display is not plotting dots at this point, and the activity number is now stable, begin switching on various electrical devices, one at a time, until the activity number begins to increase. Use this technique to identify interference sources. All systems should be activated, including trim motors, strobe lights, DME, transponder, and engines. The most common sources are alternators, strobe lights, and trim motors.

To assist in this procedure of identifying interference sources the Insight Audio Tester (P/N 2000-060) may be used.

Y0, Y1, or Y2 - Continuously displayed

Y channel bandwidth, gain, or phase error. Fault may be in display, sensor, or cable.

Check sensor cable / connector wiring for conductors YA and YB.

Exchange display and sensor with known good components.

Y0 - Intermittently displayed

This code will disappear and re-appear, randomly.

Possible loose connections on sensor cable/connector conductors YA and YB.

P - Continuously displayed

P channel failure, or **sense antenna** fault.

Check sensor cable / connector wiring for conductor PF.

Exchange display and sensor with known good components.

P - Intermittently displayed

This code will disappear and re-appear, randomly. When a real storm cell is being plotted on the display, a 'mirror image', or ambiguous storm cell will be plotted, usually with fewer dots than the real storm cell. In **Dealer Mode**, the activity number will usually be acceptably stable.

Possible loose connection on sensor cable/connector conductor PF.

In most cases, this error code is the result of repetitive voltage noise being coupled into the sense antenna at a sufficiently high rate and amplitude to cause interference with the test pulse. This causes the P channel test to fail intermittently.

Use the **Insight Audio Tester** (P/N 2000-060) to isolate the interference source, by switching various electrical equipment on, one at a time.

The most common voltage noise sources are DME, transponder, and navcom.

Ensure that all sensor cable shields are connected to pin 10 of the display's DB25 connector.

Check DME, transponder, and navcom antenna coax terminations as indicated.

Check shields, grounds, and power supply filters on relevant interfering equipment.

Z - Slow Flashing

This error code can result from loss of +8V or -8V supply, or ground to the sensor. Also, loss of the test pulse signal to the sensor, or sensor malfunction will produce this error code.

Check for the presence of +8V and -8V at the sensor 9 pin connector.

Check sensor cable/connector wiring for conductors +8V, -8V, GND, and TG.

Exchange display and sensor with known good components.

S - Continuous

Separation failure in test pulse hardware.

Return display to Insight for repair.

B - Continuous

Non-volatile memory failure.

Return display to Insight for repair.

Other Symptoms

Mirror Imaging

Symptom: Display plots a real storm cell at the proper location, as well as a 'mirror image', or ambiguous cell located 180-degrees away. Usually the 'mirror image' cell has fewer dots. This condition may be accompanied by an intermittent P error message.

For troubleshooting, see 'P-Intermittently Displayed', above.

APPENDIX B

Factory Service Procedures

Like most modern and sophisticated digital products, the Strike Finder is exceptionally reliable. After configuration during installation, Strike Finder requires no adjustment or routine maintenance.

Most problems are traceable to wiring, connectors, and interference. The instrument is the least likely cause of trouble.

When the diagnostic procedures described above indicate that the display and/or sensor require service, they must be returned to the factory. Please call Insight Avionics before shipping. Ensure that a detailed description of the problem is included with the returned instrument. It is helpful to our technicians if you tape a business card or note to the Strike Finder so that you may be contacted to discuss the problem and solution. Once repaired, the unit will be returned to you 2nd day, with shipping prepaid if it is still under warranty. **Note:** Customer pays the difference for next day shipping. If the unit is no longer under warranty, customer pays full shipping charges.

As a Strike Finder owner, if you have any concern about the operation of your instrument, discuss it first with your dealer. Insight Avionics Customer Service can be reached at any of the following numbers:

Phone: (905) 871-0733 **FAX: (905) 871-5460**

Web: insightavionics.com

We welcome the opportunity to help you, answer questions, and ensure that you have problem-free equipment that you can use with confidence. Insight provides customer support at no cost, providing you own the equipment. The Customer Service Department is available to you Monday through-Friday, between 9-am and 5-pm EST. Be ready to provide the following:

Type of Aircraft: ______________________________

Make/Model/Year: ______________________________

STRIKE FINDER® Display Serial Number: ________________

Sensor Serial Number: ________________

External RBS Serial Number: __________

APPENDIX C

Strike Finder Technical Specifications

SIZE:

Display/Processor:
3.19" (8.10 cm) high
3.19" (8.10 cm) wide
9.50" (24.13 cm) deep (connector adds 1.90" (4.83 cm)

Sensor:
0.83" (2.11 cm) high (gasket adds 0.13" (0.33 cm)
3.76" (9.55 cm) wide
5.50" (13.97 cm) deep

MOUNTING:

Display/Processor:
Standard 3.125" (7.94 cm) round hole + four #6-32 screws (rear mount),
or 3ATIF flanged mounting, or 3ATI front mounting (with clamp)

Sensor:
Surface mount (with 2 or 4 #4 screws)

WEIGHT:

Display/Processor:
1.3 lb. (0.58 kg.)

Sensor:
0.77 lb. (0.35 kg.)

TEMPERATURE:

Display/Processor:
-20 to +55˚C (-4 to +131˚F)

Sensor:
-55 to +70˚C (-67 to +158˚F)

ALTITUDE:

Display/Processor:
55,000 feet (maximum)

Sensor:
55,000 feet (maximum)

COOLING:
Conduction

STRIKE RANGES:
25, 50, 100 & 200 nm

STRIKE VIEW ANGLE:
360˚

TSO COMPLIANCE:
TSO-C110a

RTCA COMPLIANCE:

Display /Processor Environmental:
DO-160B Category FICAPKSXXXXXXZBABAAA

Display/Processor Software:
DO-178B Level 2

Sensor Environmental:
DO-160B Category F2ACY34JLMXSFDXSZBABAAA

POWER REQUIREMENTS:

Input Voltage:	10 to 33 VDC
Current:	0.7A @ 14V
	0.35A @ 28V

U.S. PATENT NUMBERS
5.245.274, 5.408.175, 5.500.586, 5.500.602, 5.502.371, 5.504.421
Others pending

APPENDIX D

Relative bearing stabilizer (RBS)

Introduction

The **Relative Bearing Stabilizer** is a plug-in module that automatically repositions strike dots, relative to the aircraft heading, during turns. This is achieved without the Strike Finder having to be slaved to an on-board compass system —no aircraft compass system needed. The **RBS** connected to Strike Finder is all that is required, *(see Figure 42)*.

Description

The **RBS** is powered through Strike Finder circuitry without additional wiring. New software algorithms employ data from integrated motion sensors and data processors to determine heading changes. No field configuration or calibration is required after factory testing and installation.

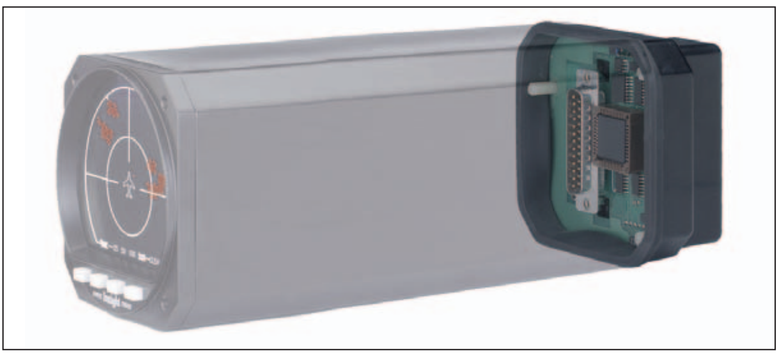


Figure 42. External RBS Snaps on Back

Installation

When factory installed, the **Relative Bearing Stabilizer** is mounted within the standard Strike Finder housing, (modification “D” and newer units).

Operation

Upon system start-up or reboot, a five minute warm-up is needed to achieve full stabilization (**note** that RBS action is completely locked out for the first minute after power-up). If the aircraft heading is changed during the five minute warm-up period, the strike dots may drift somewhat from correct positioning. Use the clear function before take-off, pausing to acquire strike information and storm locations if the warm-up period is not complete.

In-flight operation is fully automatic.

RBS Module Technical Specifications

SIZE:
Internal Module 2000-050:
3.00 (7.62 cm) high
3.00 (7.62 cm) wide
1.40 (3.56 cm) deep
Note: This module mounts inside the SF2000 Display, and therefore does not affect its outside dimensions.

EXTERNAL MODULE 2000-051:
3.19 (8.10 cm) high
3.19 (8.10 cm) wide
1.60 (4.06 cm) deep
Note: This positions the SF2000 Display connector
0.80 (2.03cm.) further to the rear.

MOUNTING:
Internal Module:
Integral with SF2000 Display main board. (SF 2000 Mod "D" or later).

EXTERNAL MODULE:
Interfaces directly with the SF2000 Display connector and the Sensor cable connector.

WEIGHT:
0.3 lbs. (0.13 kg.)

TEMPERATURE:
-20 to +55C (-4 to +131F)

ALTITUDE:
-1,000 to 55,000 feet (maximum)

COOLING:
Conduction

BEARING STABILITY:
Within +/-10˚, for 90˚ of heading change.

TSO COMPLIANCE:
TSO-C110a

RTCA COMPLIANCE:
Environmental:
DO-160B Category
FICAPKSXXXXXXZBABAAA

SOFTWARE:
DO-178B Level 2

POWER REQUIREMENTS:
Power:
0.5 Watts

APPENDIX E

Questions and Answers

[1] How long does a dot stay on the display?
The dots will stay on the display as long as strikes occur.

[2] How often or when should I press the clear display button?
Clear the Strike Finder display to evaluate storm intensity.
See Display Interpretation section for details.

[3] If I have selected the 25 nm range view, will Strike Finder be still gathering data at 200 nm?
Yes, Strike Finder is always gathering and analyzing data out to 200 nm.

[4] Does size or brightness of dots indicate strength of lightning strikes?
No. The severity of the lightning strikes are assessed in several ways.
See Assessing Storm Severity section for details.

[5] What is the cause of an X0 error appearing intermittently?
The X0 error message indicates failure of Strike Finder self-test. The failure may be temporary or permanent.
See the Trouble Shooting section for details.

[6] Is the Strike Finder a Heading-up or a North-up display?
Strike Finder is a Heading-up display.

[7] Will Strike Finder slave to an autopilot?
No, it may be slaved to a 400 Hz synchro-resolver interface, or a Bendix/King KCS-55 stepper interface.

[8] Can Strike Finder be interfaced to a radar display?
No, all radar display instruments have proprietary interfaces.

[9] I see "flickering" dots, what does this mean?
Flickering may be caused by a faulty plasma display, or a faulty photo cell. Call Insight technical support.

[10] Can Strike Finder detect anything other than thunderstorms?
No, Strike Finder will only detect lightning strikes.

APPENDIX F

Helpful Insight

The following are excerpts from Avionics Magazine, August 1988, with permission from the publishers and author:

Electrostatic Charging In Flight

by: Jay D. Cline, Dayton-Granger, Inc.

It is widely known that electrostatic charging of aircraft in flight generates radio frequency noise which disrupts navigation and communications. Such charging results from several sources. For example, flight through precipitation, electric crossfields and engine produced ionization. RF noise is also generated by streamer currents on the plastic frontal area of an aircraft during precipitation encounters and corona discharge between airframe members.

This can affect almost all aircraft, from General Aviation through airline transport and military supersonic. At ground speeds of two to ten nautical miles per minute, loss of navigation or communication due to streaming, corona or arcing noise can be serious, especially while maneuvering near airports in instrument conditions.

Static Discharge Story

In the early days of aviation, flying was done primarily during daylight by visual reference such as highways, railroad tracks and rivers. Communication was done by signal lights and wing waggling.

As the reliability of aircraft improved, flying under all conditions became practical, creating demands for improved communications and navigation systems. However, during the early use of these systems, pilots quickly became aware of a form of severe radio interference which hampered the performance of the existing navigation and communication systems.

Experience showed a correlation between RF noise and flight through rain, snow and clouds. Hence, pilots became very concerned because the conditions which caused the most **“precipitation static” (P-Static)** occurred when navigation and communication needs were the greatest.

Aircraft Charging

These effects occur as an airplane flies through freezing rain, ice crystals, dust, sand and snow. Contact with these particles leaves a positive or negative charge on the air frame. As the aircraft charge builds, a potential is reached where the charge leaks off the aircraft and antennas, generating broad band radio frequency noise. This interferes with ADF, HF, as well as VHF and VOR receivers.

Cross-field currents are generated on aircraft flying in clear air beneath a charged cloud layer. The magnitude is a function of the potential of the cloud with reference to ground and the speed of the aircraft.

Streamering

This noise source is generated over dielectric surfaces such as radomes, fiberglass winglets and other fiberglass panels positioned on frontal impact areas of the aircraft. As particles strike, they deposit an electron on the dielectric surface. As more particles impact this isolated pool, the voltage increases until it reaches the flash over point. When the pool of charge flashes over the surface of the dielectric material, it generates broad band radio frequency noise.

This phenomenon is also observed over metal surfaces painted with a high electric strength paint, or paint buffed to a high polish. In this case, charges accumulating on the paint generate streamers from a rivet head or screw fastener. Streamering can be solved by coating the non-conductive surface with high resistance paint. Such paint quietly bleeds the charged particles to the aircraft fuselage.

Corona Noise

This occurs when the aircraft accumulates sufficient charge due to aircraft charging and/or cross fields to ionize air around wing tips, vertical or horizontal stabilizers and the other protrusions. Over 5,000,000 volts have been measured on General Aviation aircraft in flight. As current bleeds off trailing edges, it generates radio frequencies that sound like loud hissing in aircraft receivers. The charging also causes antennas to go into corona (bleeding off charge). When this happens the noise appears like a strong signal to the receiver. In some cases the automatic gain control circuit, sensing noise as a strong signal, desensitizes the receiver to the point where the receiver may go perfectly quiet. The Pilot assumes no one is calling, but in reality corona current has, for all practical purposes, shut down the receiver. When aircraft voltage lessens and antenna corona current stops, receiver AGC returns to normal and communications can continue.

The pilot is seldom aware of what happened. When communications are reestablished, ATC may assume the pilot was not paying attention to his radio.

Solutions to corona noise include antennas that are insulated from space and static discharges positioned where the aircraft is most likely to go into corona; wing tips, vertical and horizontal stabilizers are examples. Static discharges bleed off charge quietly. They lower aircraft voltage below a level where antennas go into corona.

Arcing Noise

This interference is generated by an isolated piece of metal situated on an aircraft where, as the aircraft charges, it reaches a potential at which a spark jumps the gap from aircraft structure to isolated metal. The spark can produce broad band noise extending through 1,000 MHz. The cure is to locate the isolated metal and bond it to the aircraft structure grounding strap. To locate this problem, the aircraft can be probed with an **Electrostatic Test Set** while monitoring aircraft receivers for arcing noise. When the noise area is identified, physical identification can isolate the piece of metal. These and other solutions can greatly lessen the effect of environmentally induced noise while in flight.

During WWII it was necessary to have navigation and communication systems that were reliable in all weather conditions. To address the interference problem the Naval Air Development Center (NADC) sponsored a program to develop methods to reduce noise created by **P-Static.** As a result of this program, Dayton-Granger invented and patented the first static dischargers.

Continued research and development in the 1950's led a static discharger which adopted a new concept that was far superior in noise suppression than anything else. This patented device, designed the Granger Associated (later to be a part of Dayton-Granger) was the Nullified Discharger which is still the industry standard today.

NOTES